SECTION 7- THORAX ASSEMBLY

7.1 Thorax Assembly Description and Features

The thorax assembly of the THOR dummy integrates components from the shoulder, spine, rib cage, and upper abdomen assemblies. This section of the manual describes the correct procedure to assemble the entire thorax of the THOR dummy, bringing several subassemblies together. The thorax assembly is shown in **Figure 7.1**.

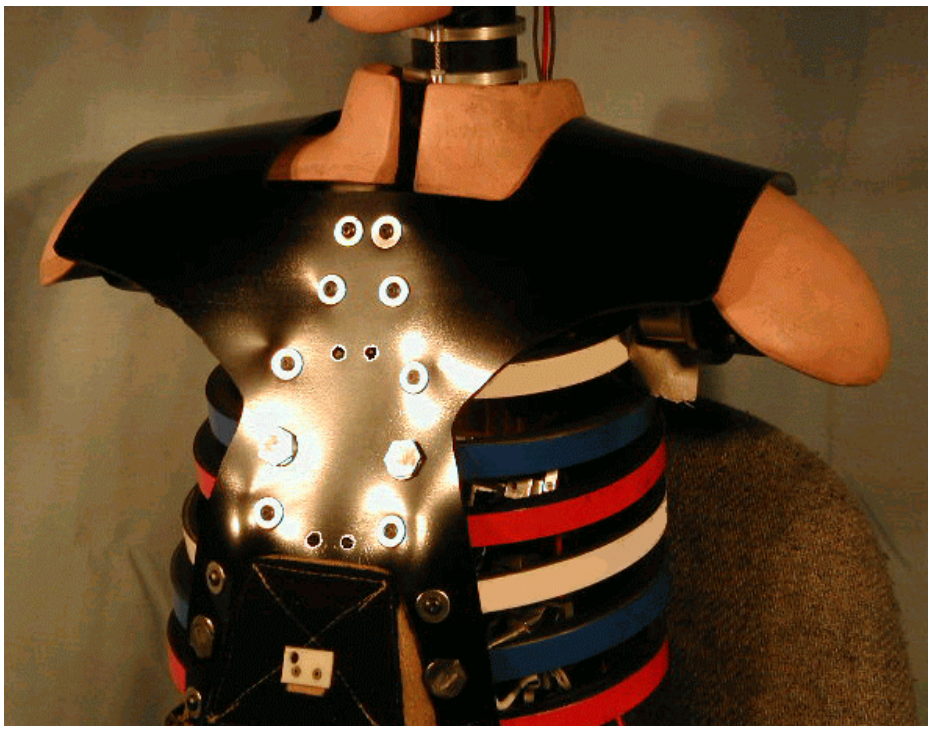

Figure 7.1- Thorax assembly

The advanced thorax assembly features extensive instrumentation which is used to measure and record the deflections, forces, and accelerations that this region experiences during testing, as shown in **Figure 7.2**. The deflection of the rib cage is measured at four distinct points. These points are measured using the CRUX units which capture the deformation in three-dimensions. The forces on the thorax assembly are measured at the T12 location using a five-axis load cell. (This load cell is considered part of the Spine assembly - Section 6.) A triaxial accelerometer is located at the center of gravity of the thorax to measure the acceleration along the three principle axes. A uniaxial accelerometer is positioned on the sternal plate to measure acceleration at this location.

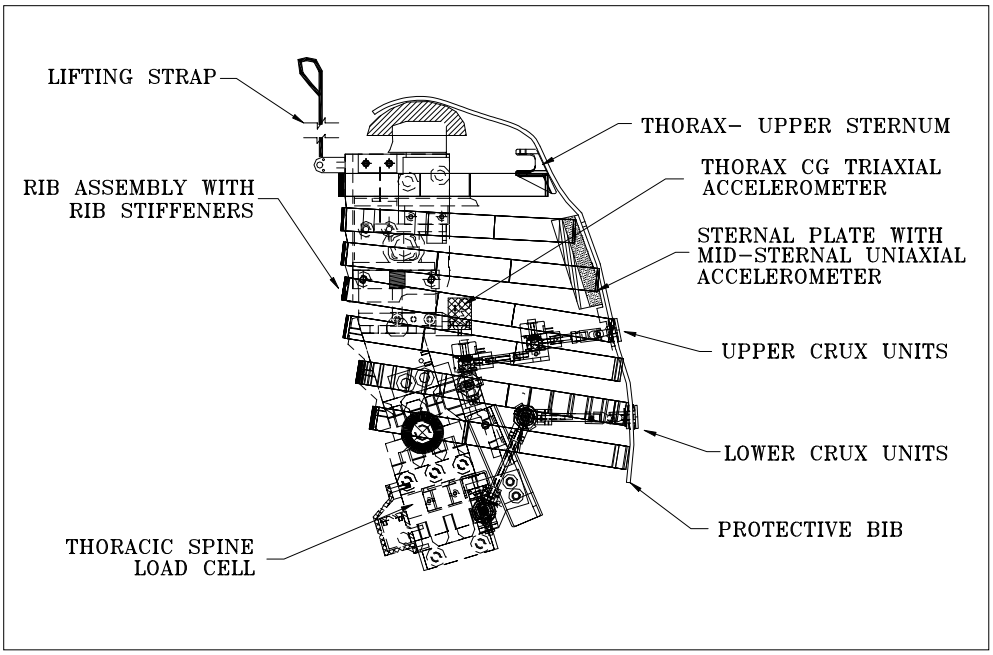

Figure 7.2- Thorax instrumentation locations

7.2 Thorax Assembly

7.2.1 Parts List

The part list and all quantities for the thorax assembly are listed in Appendix I - Bill of Materials under the Thorax subsection. Refer to drawing T1TXM000 in the THOR drawing set for a detailed mechanical assembly drawing. **Figure 7.3** is a photograph of the seven ribs, rib stiffeners, and thorax CG mounting bracket to the thorax assembly.

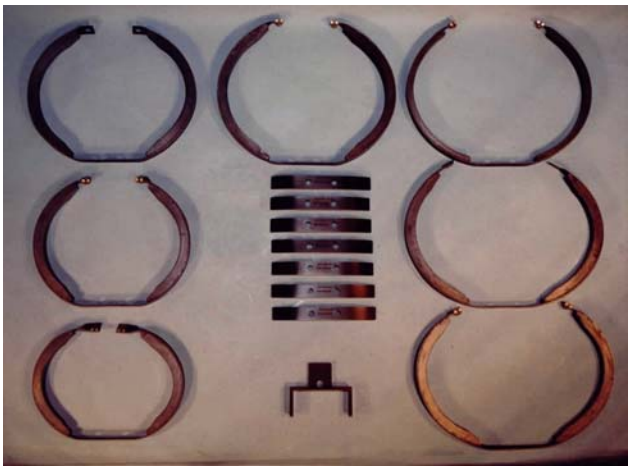

Figure 7.3- Thorax exploded assembly

7.2.2 Assembling the Thorax Components

The following procedure is a step-by-step description of the assembly procedure for the thorax components. Completion and integration of several subassemblies is required to create the thorax assembly. The numbers provided in ( ) refer to a specific drawing / part number of each part. The numbers noted in { } after the bolt size indicate the hex wrench size required to perform that assembly step. All bolts should be tightened to the torque specifications provided in Section 2.1.3- Bolt Torque Values.

1. Assemble the complete spine assembly as described in Section 6.2- Spine Assembly. The completed spine assembly should include all mechanical components from the pelvis to the neck pitch change mechanism, as well as all relevant instrumentation: 4 tilt sensors, T1 and T12 triaxial accelerometers, and the T12 load cell. The head and neck should not be mounted at this point.

2. Mount the shoulder components onto the upper thoracic spine weldment as described in Section 8.2- Shoulder Assembly. This assembly should include all related shoulder hardware for both the left- and right-hand sides including rubber stops, rib #1 support, and shoulder blocks.

3. Mount the upper abdomen / CRUX / thoracic instrumentation bracket onto the spine assembly as described in Sections 9 and 16.

4. A triaxial accelerometer unit can be attached to a mounting plate which will be attached at the thorax CG. The THOR dummy was designed to accept mounting plates for both the triaxial cube and tri-pack accelerometer configurations. The mounting procedure for each type of triaxial accelerometer is explained in detail below:

   Triaxial cube-type accelerometers: Refer to drawing T1TXM200 for additional details. This type of triaxial accelerometer is a one-piece unit (T1INM120). The unit is attached to the Thorax CG Mounting Plate (T1TXM211) using two #4-40 x 1/4" FHSCS {1/16}. The Thorax CG Mounting Plate is then mounted to the Thorax CG Mounting Bracket (T1TXM210) using two #4-40 x 3/8" FHSCS {1/16}. The stamped markings on the unit are oriented in the following manner: +X forward, +Y left, +Z up. The axes must be corrected to the SAE convention in the DAQ system wiring. The Thorax CG Mounting Bracket is mounted to the front of the Upper Thoracic Flex Joint Bottom Plate (T1SPM312) using four #10-32 x ½" FHSCS {1/8}. The wire from the triaxial cube is routed to the left of the thorax and is bundled with the LTS tilt sensor wire. These wires are secured with a #10-32 x ½" BHSCS {1/8} to the middle hole on the left-side of the Thorax CG Mounting Bracket using a 3/16" wire clamp. **Figure 7.4** shows the completed installation of this unit.

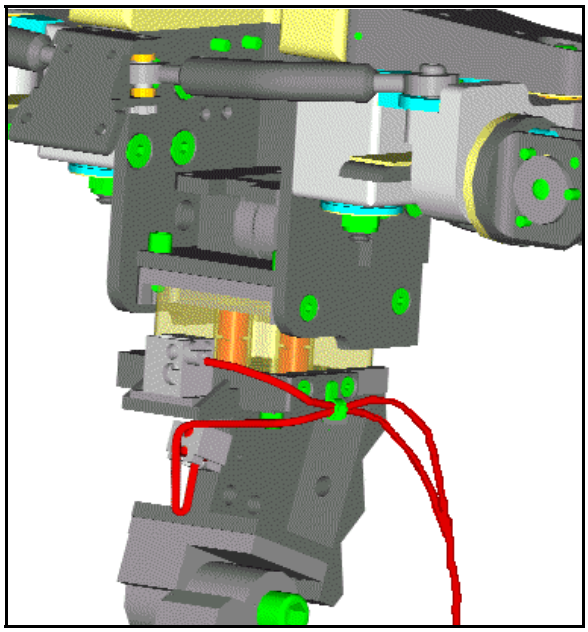

Figure 7.4- Thorax CG triaxial accelerometer installed

Tri-Pack-type accelerometers: Refer to drawing T1TXM201 for additional details. This type of triaxial accelerometer consists of a Tri-Pack Block (T1INM130) which holds three uniaxial accelerometers (T1INM110) on the outer surface. The three uniaxial accelerometers are mounted on the tri-pack block using six #0-80 x 1/4" SHCS {0.05}. The Thorax CG Tri-Pack Mounting Plate (T1TXM212) is mounted to the top side of the Thorax CG Mounting Bracket (T1TXM210) using two #4-40 x 3/8" FHSCS {1/16}, as shown in **Figure 7.5**.

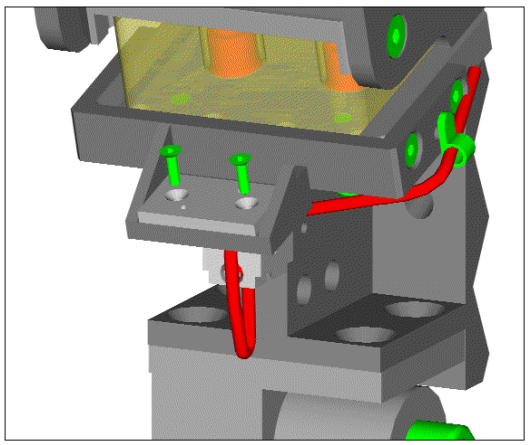

Figure 7.5- Tri-pack mounting plate installed

The

instrumented Tri-Pack block is mounted to the mounting plate using two #2-56 x 9/16" SHCS {5/64}. The orientation of the accelerometers is: +X rear, +Y right, +Z up. The axes must be corrected to the SAE convention in the DAQ system wiring. The Thorax CG Mounting Bracket is mounted to the front of the Upper Thoracic Flex Joint Bottom Plate (T1SPM312) using four #10-32 x ½" FHSCS {1/8}. The wires from the tri-pack cube is routed to the left of the thorax and are bundled with the LTS tilt sensor wire. These wires are secured with a #10-32 x ½" BHSCS {1/8} to the middle hole on the left-side of the Thorax CG Mounting Bracket using a 3/16" wire clamp. **Figure 7.6** shows the completed installation of this unit.

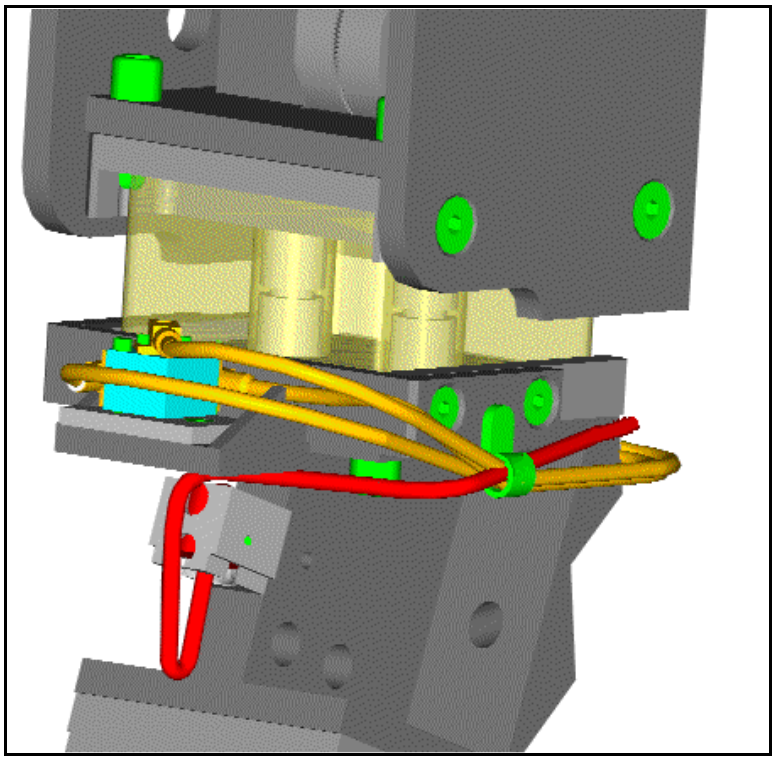

Figure 7.6- Tri-pack block installed on Thorax CG bracket

5. Pass instrumentation cables from lower neck load cell and the neck tilt sensor through hole in rear of upper thoracic spine weldment, as shown in **Figure 7.7**. Mount the neck to the spine as described in Section 5.2.4- Attaching the Neck to the Spine.

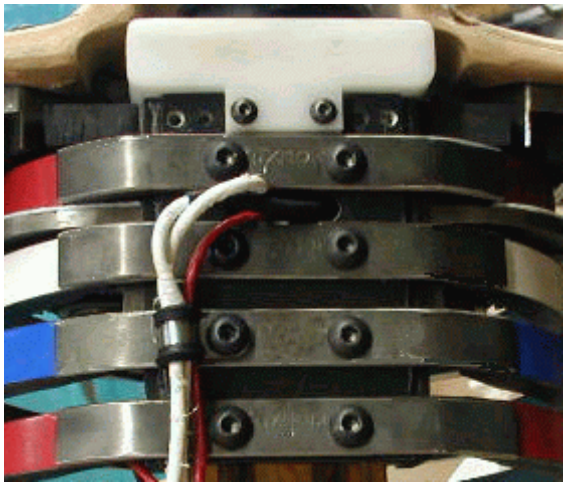

Figure 7.7- Lower neck instrumentation cables

6. Position Elliptical Rib #1 (T1TXM310) as shown in **Figure 7.9**. This rib assembly is marked with the number "1", the mark being oriented correctly to denote the top and bottom of the rib. The rib must be located above the rib support bracket and the rear of the rib should be centered over the Upper Thoracic Spine Weldment to line up the holes. Since the shoulder hardware can make insertion of this rib troublesome, the following description may be helpful for positioning this rib: Pass the open end of rib around the right-hand clavicle rod at the front of the dummy and above the rib support on the right-hand side (with the open end facing the rear of the dummy). Rotate the rib (clockwise as viewed from the top) around the upper thoracic spine until the open end is again at the front (i.e. the rib must pass across the rear of the upper thoracic spine weldment and above the other rib support).

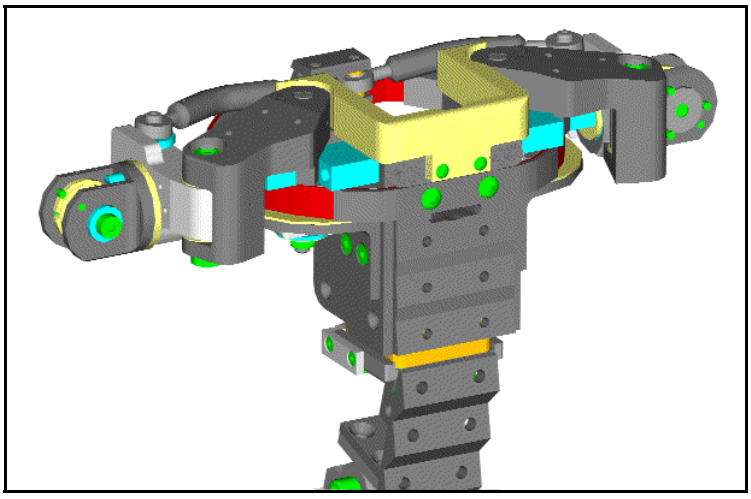

Figure 7.8- Rib #1 placement/installation

7. Position the Elliptical Rib Stiffener #1 (T1TXM010) over the back of rib #1 and align the mounting holes. Secure the Elliptical Rib Stiffener #1 and Rib #1 to the back of the upper thoracic spine weldment with two 5/6-24 x ½" BHSCS-NP {3/16}.

NOTE: The rib stiffeners on the THOR dummy are not interchangeable. Each stiffener is designed for a specific rib position and is marked #1 - #7 to correspond with the ribs.

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8. Position Elliptical Rib #2 (T1TXM320) and Elliptical Rib Stiffener #2 (T1TXM011) on the back of the upper thoracic spine weldment and secure with two 5/16-24 x ½" BHSCS-NP {3/16}, as shown in **Figure 7.9**.

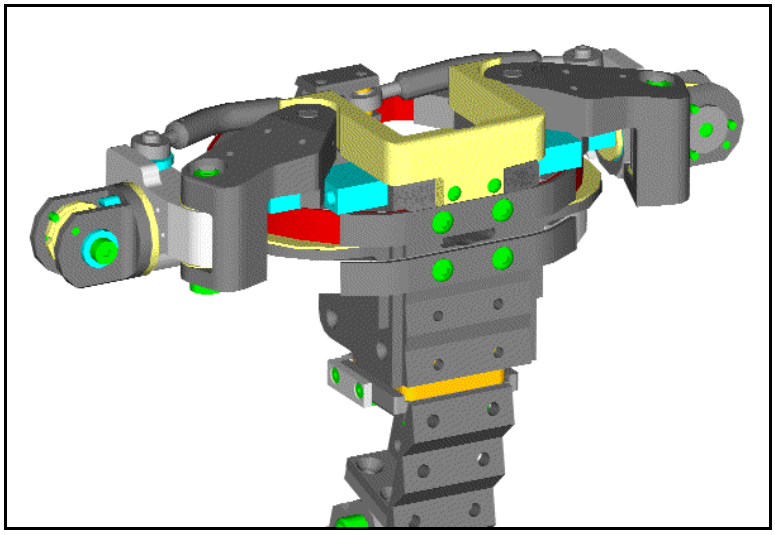

Figure 7.9- Positioning of Rib #2

9. Position Elliptical Rib #3 (T1TXM330) and Elliptical Rib Stiffener #3 (T1TXM012) on the back of the upper thoracic spine weldment. With a 1/4" wire clamp and one of the two 5/16-24 x ½" BHSCS-NP {3/16} used to secure the rib to the back of the upper thoracic spine weldment, strain relieve the lower neck load cell wires and the neck tilt sensor wire to the back of the Elliptical Rib Stiffener #3 as shown in **Figure 7.7**. Use the other bolt to fully secure the Elliptical Rib #3 to the back of the spine.

NOTE: Some slack must be provide in the lower neck load cell wires and neck tilt sensor wire before strain relieving it to allow for the adjustment of the neck pitch at the Neck Pitch Change Mechanism (T1SPM200).

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10. Position Elliptical Rib #4 (T1TXM340) and Elliptical Rib Stiffener #4 (T1TXM013)

on the back of the upper thoracic spine weldment and secure with two 5/16-24 x 3/8" BHSCS-NP {3/16} rib bolts.

11. Position Elliptical Rib #5 (T1TXM350) and Elliptical Rib Stiffener #5 (T1TXM014) on the back of the upper thoracic spine weldment and secure with two 5/16-24 x 3/8" BHSCS-NP {3/16}.

13. Position Elliptical Rib #6 (T1TXM360) and Elliptical Rib Stiffener #6 (T1TXM015) on the back of the upper thoracic spine weldment and secure with two 5/16-24 x ½" BHSCS-NP {3/16}.

14. Position Elliptical Rib #7 (T1TXM370) and Elliptical Rib Stiffener #7 (T1TXM016) on the back of the upper thoracic spine weldment and secure with two 5/16-24 x ½" BHSCS-NP {3/16}. The completed rib assembly is shown in **Figures 7.10** and **7.11**.

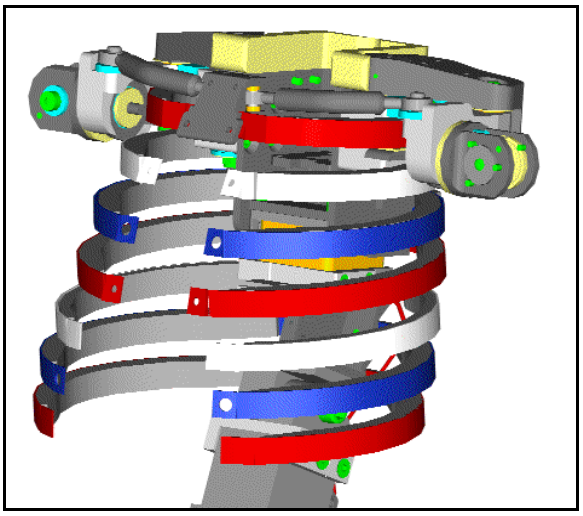

Figure 7.10- Complete rib assembly (front)

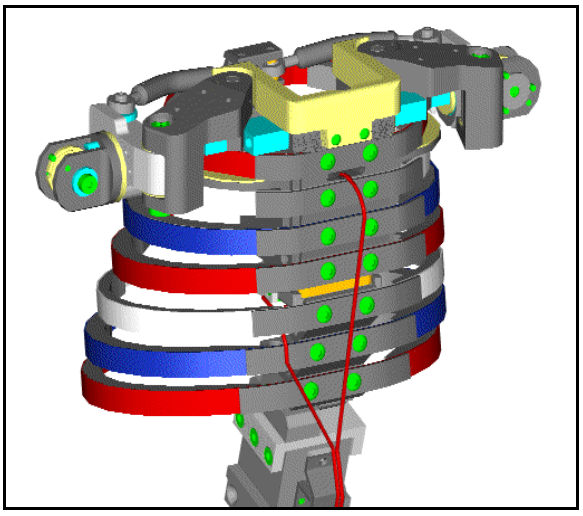

Figure 7.11- Complete rib assembly (rear)

15. Gather the wire bundle from the head and neck instrumentation (except the lower neck load cell wire). Holding the bundle together, measure 13.5" down along the wire bundle from the bottom of the head mounting plate. Centered at this point, wrap the wire bundle with electrical tape, as shown in **Figure 7.12**, to provide enough thickness to allow the Spine Wire Cover Assembly (T1TXM040) to hold it securely in place.

NOTE: It is critical to provide the correct amount of slack wire above this clamp to allow the head and neck to have free motion in flexion and extension.

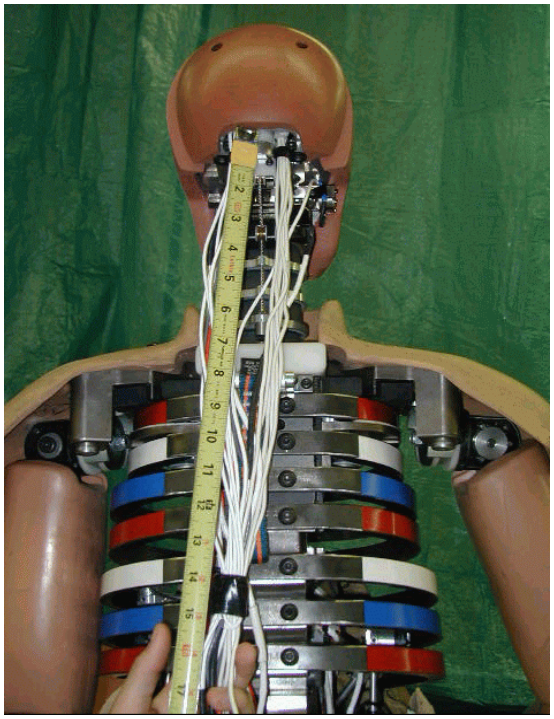

Figure 7.12- Measuring the wire bundle

Center the nylon sling on the Spine Wire Cover Shaft (T1TXM042) and use two #10-32 x 5/8" BHSCS {1/8} to secure the Spine Wire Cover Assembly and the bundled wires to the top of the Upper Thoracic Spine Weldment (T1SPW120) as shown in **Figure 7.13** .

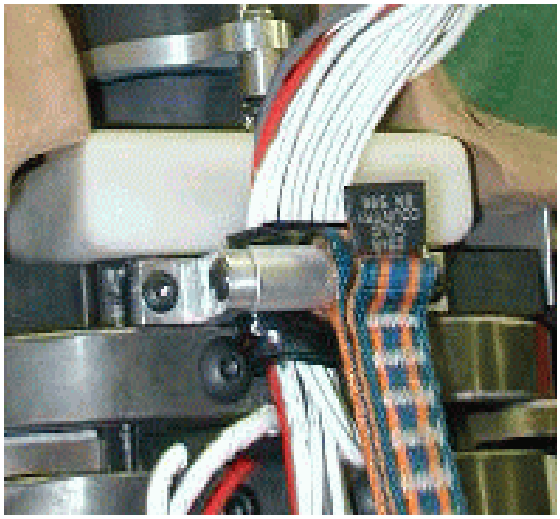

Figure 7.13- Head/Neck wire bundle secured with spine wire cover

16. Lay the Urethane Outer Bib (T1TXM110) on a table with the outer (front) surface

down. Position the Mid-Sternum Assembly (T1MSM000) on top of the bib. Orient the assembly so that the weight is closer to the top of the bib. Using four Sternum Bolts (T1TXM140) secure the Mid-Sternum Assembly to the Urethane Outer Bib as shown in **Figure 7.14**.

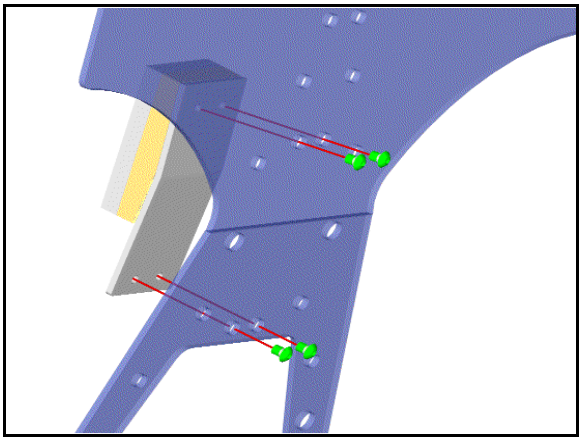

Figure 7.14- Attachment of Mid-Sternum Assembly

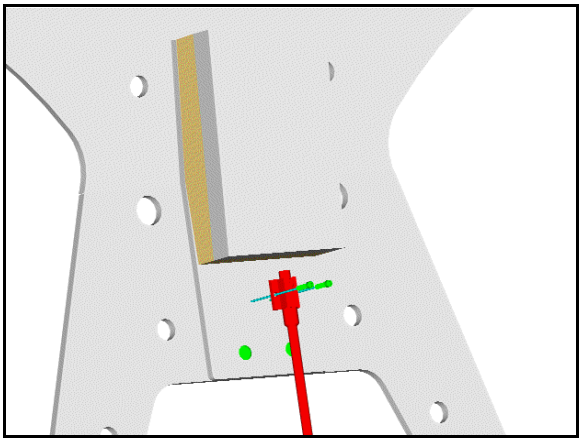

Figure 7.15- Attachment of uniaxial accelerometer to Mid-Sternum Assembly

17. The THOR dummy was designed with a set of mounting holes for a uniaxial accelerometer (T1INM110) on the mid-sternum plate. The accelerometer can be mounted at this time using two #0-80 x 1/8" SHCS {0.050} as shown in **Figure 7.15.** The bolts should be tightened securely, but excessive force is NOT required.

WARNING: The application of excessive torque to the 0-80 accelerometer mounting bolts may cause permanent damage to the accelerometer and the bolt threads.

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18. Verify that the #10-32 clip nuts have been installed onto the outer ends of ribs #1, 2, 4, 5, and 7. The clip-nuts are used to install the bib to the rib assembly.

19. Bolt the Bib Assembly (T1TXM100) to the elliptical rib #7 at the front of the dummy using two of the Thorax Bolts (T1TXM141) {1/8}. The bolt should pass through the urethane outer bib, the upper abdomen flap hole, and into the clip nut on the end of rib #7. Perform this procedure for the left and right-hand sides of the rib.

20. The next attachment point for the bib is Rib #6 where the lower CRUX units are connected. Pass the universal joint end from the Lower Right Crux Unit (T1CXM003) through the hole in the end of the right-hand side of the sixth rib, through the center hole in the right hand side upper abdomen bag flap, and through the Bib Assembly. Attach the front of the Lower Right Crux Unit to the Bib Assembly with a Crux Rib Connection Bolt (T1CXM010) {3/4}. The U-joint is designed for limited rotation on the end of the CRUX arm and should be set to the

middle of the rotation range while the unit is in the rib cage as shown in **Figure 7.16**.

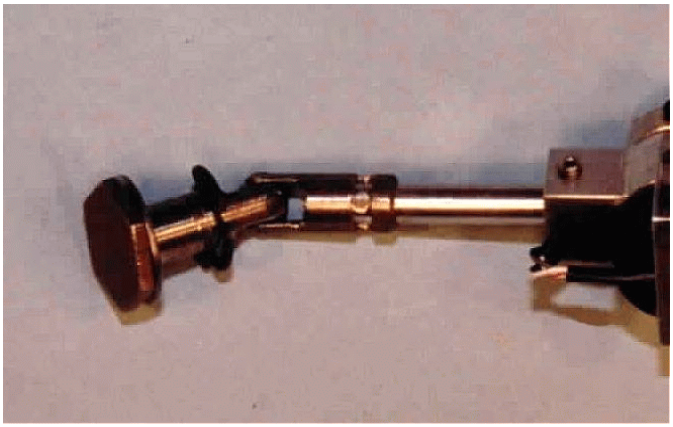

Figure 7.16- Proper positioning of the U-Joint in its range of motion

21. Repeat Step 20 on the left-hand side for the Lower Left CRUX Unit (T1CXM004).

NOTE: A simple trick to set the U-joint in the middle of its range of motion is to tighten the CRUX rib connecting bolt using a 3/4" wrench until contact is felt. The U-joint will be at one end of its range of motion. Turn the rib bolt slightly counterclockwise, causing the U-joint to rotate on the CRUX arm until it is centered. The position of the U-joint must be visually verified.

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22. Bolt the Bib Assembly to the Elliptical Rib #5 at the front of the dummy. Connect the bib to the ends of the ribs using two of the Thorax Bolts (T1TXM141) {1/8}. For rib #5, the bolt should pass through the urethane outer bib, the upper abdomen flap hole, and into the clip nut on the end of rib #5. Perform this procedure for the left- and right-hand sides of the rib.

23. Bundle the instrument wire from the mid-sternal uniaxial accelerometer with the upper abdomen uniaxial accelerometer wire. Pass the wires around the left side of the spine. Secure it into the wire clamp, located on the upper abdomen assembly, used to fasten the upper and lower left CRUX wires, as shown in **Figure 7.17**. The cables are routed out the left side of the dummy to join the bundle of cables running down the spine.

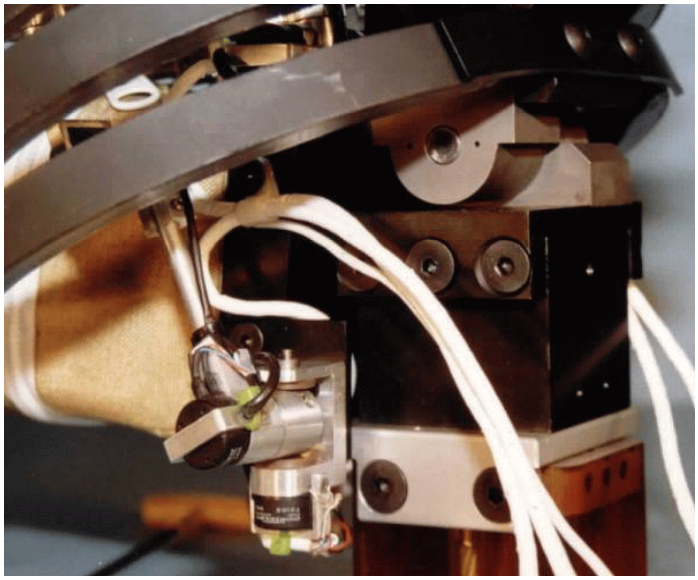

Figure 7.17- Wire routing for the CRUX and mid sternal accelerometer cables

24. Bolt the Bib Assembly to Elliptical Rib #4 at the front of the dummy. Connect the Bib Assembly to the ends of the rib using two of the Thorax Bolts (T1TXM141) {1/8}. For rib #4, the bolt should pass through the Bib Assembly, and into the clip nut on the end of rib #4. Perform this procedure for the left- and right-hand sides of the rib.

25. Pass the universal joint end from the Upper Right Crux Unit (T1CXM001) through the hole in the end of the right-hand side of rib #3 and the matching hole in the Bib Assembly. Attach the front of the Upper Right Crux Unit to the Bib Assembly with a Crux Rib Connection Bolt (T1CXM010) {3/4}. The U-joint is designed for limited rotation on the end of the CRUX arm and should be set to the middle of the rotation range while the unit is in the rib cage as shown in **Figure 7.16**.

26. Repeat Step 25 on the left-hand side for the Upper Left CRUX Unit (T1CXM002).

27. Bolt the Bib Assembly to Elliptical Rib #2 at the front of the dummy. Connect the Bib Assembly to the ends of the rib using two Thorax Bolts (T1TXM141) {1/8}. For rib #2, the bolt should pass through the Bib Assembly and into the clip nut on the end of rib #2. Perform this procedure for the left- and right-hand sides of the rib.

28. Bolt the Bib Assembly to Elliptical Rib #1 at the front of the dummy. Connect the bib to the ends of the ribs using two Thorax Bolts (T1TXM141) {1/8}. For rib #1, the bolt should pass through the Bib Assembly, through the lower set of holes in the Thorax Upper Sternum Plate (T1SHM018), and into the clip nut on the end of rib #1. Perform this procedure for the left- and right-hand sides of the rib.

29. Bolt the top of the thorax upper sternum plate to the bib assembly using two Sternum Bolts {1/8} as shown in **Figure 7.18**. The bolts should pass through the Bib Assembly and thread into the upper set of holes in the thorax upper sternum plate.

Figure 7.18- Attach the bib to the upper sternal plate

7.3 Adjusting the Thorax Assembly

No adjustments are required for the thorax assembly.

7.4 Wire Routing and Electrical Connections

The wire routing for instrumentation in the thorax assembly is fairly straightforward. Each instrument in this assembly will be covered individually. Since the thorax assembly involves several separate subassemblies, it may also be necessary to refer to the sections on the Spine, Upper Abdomen, and Instrumentation to develop a complete understanding of these instrumentation systems.

CRUX Units: The routing of the wires from the CRUX units is discussed in Section 16 - CRUX Assembly . The wires from the upper and lower CRUX units are strain-relieved with a wire clamp attached to each side of the Upper Abdomen Spine Mount (T1UAM100) with a 1/4-20 x ½" BHSCS {5/32}. The wires are then routed on the left and right sides of the spine assembly and exit the thorax below rib #7 to joint the bundle of wires running down the dummy's spine.

Mid-Sternum Uniaxial Accelerometer: Bundle the instrument wire from the mid-sternal uniaxial accelerometer with the upper abdomen uniaxial accelerometer wire. Pass these wires around the left side of the spine and secure it into the wire clamp, located on the upper abdomen assembly, used to fasten the upper and lower left CRUX wires. The

cables are routed out the left side of the dummy to joint the bundle of cables running down the spine.

Thorax CG Triaxial Accelerometer: The wire from the thorax CG triaxial cube exits to the left and is bundled with the LTS tilt sensor wire. These wires are secured with a #10-32 x ½" BHSCS {1/8} to the left-side of the Thorax CG Bracket using a 3/16" wire clamp.

7.5 Certification of Thorax Assembly

The thorax assembly is certified by the manufacturer using dynamic impact tests. Testing is performed on the upper and lower rib cage. Certification procedures for these tests are described in the THOR Certification Manual - available from the manufacturer as a separate publication.

7.6 Inspection and Repairs

After a test series has been performed, several inspections should be performed to ensure the dummy's integrity has remained intact. Good engineering judgement should be used to determine the frequency of these inspections; however, the manufacturer recommends a thorough inspection upon completion of twenty tests. The frequency of the inspections should increase if the tests are particularly severe or unusual data signals are being recorded. These electrical and mechanical inspections are most easily performed during a dummy disassembly. The disassembly of the thorax components can be performed by simply reversing the assembly procedure.

7.6.1 Electrical Inspections (Instrumentation Check)

This inspection should begin with the visual and tactile inspection of all the instrument wires. The wires should be inspected for nicks, cuts, pinch points, and damaged electrical connections which would prevent the signals from being transferred properly to the data acquisition system. The instrument wires should be checked to ensure that they are properly strain-relieved. A more detailed check on the individual instruments is covered in Section 15- Instrumentation and Wiring.

7.6.2 Mechanical Inspection

Several components in the thorax assembly require a visual inspection to determine if they are still functioning properly. This mechanical inspection should also involve a quick check for any loose bolts in the main assembly. Each area of mechanical inspection will be covered in detail below. Please contact the manufacturer regarding questions about items that fail the mechanical inspection.

NOTE: Use of nylon pellet bolts was specified for the spine assembly to prevent bolts from loosening during the impact and vibrations associated with a crash pulse. If it is necessary to replace a bolt in the spine assembly, it is advantageous to use a new bolt with a fresh pellet. Reusing old pellet bolts will reduce their effectiveness.

Ribs: The following checklist should be used when inspecting the ribs for post-test damage:

- Check each end of the damping material for debonding or cracking. This check should involve a visual inspection with the aid of a magnifying lens if possible
- Check rib steel for deformation (spine attachment, sides and bib attachment) Deformation needs to be checked in the X, Y, and Z directions. Drawings may be used as reference for comparison
- Check rib stiffeners for bending. There should not be any visible gaps between the ribs and the rib stiffeners. Drawings may be used as reference for comparison
- Check damping material for physical damage (top, bottom and interior surface). Check for cuts, nicks, deformation

CRUX Units: The following checklist should be used when inspecting the CRUX units for post-test damage:

- Check tightness of rib / bib connection bolts and CRUX Rib connection bolts
- Check that U-joints for CRUX units are still positioned in the middle range of their allowable rotation

Bibs: The following checklist should be used when inspecting the bibs for post-test damage:

- Check all bolt locations for tearing / washer penetration

Mid-Sternum Plate: The following checklist should be used when inspecting the mid-sternal plate for post-test damage:

- Check plate for excessive bending using the drawings as a reference
- Check uniaxial accelerometer bolts for tightness and tighten if necessary